Module 3: Jump Capacity Monitoring Test.

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Jumping ability refers to an athlete's capacity to propel themselves vertically, laterally, or horizontally off the ground, and is considered a complex human movement that requires a high level of motor coordination between the upper and lower body (1).

It can be assessed in various ways, including vertical jumps, countermovement jumps, one-leg jumps, or horizontal jumps, among others. The maximum jump height achieved in vertical jumps or the maximum distance covered in horizontal jumps serves as an indicator of leg muscle power and explosive strength. This metric is crucial in many sports such as football (2), volleyball (3), basketball (4), and handball (5), where the ability to jump higher can significantly impact performance (6).

Jump power refers to how quickly force can be generated to perform a jump. It is calculated by multiplying the force applied to the body during the jump by the speed at which the force is exerted. In simple terms, it’s a combination of strength and speed. An athlete with high jump power can produce a large amount of force in a short time, resulting in a higher or more powerful jump (7).

Explosive strength is the ability of the body to generate a significant amount of force in a short period of time. This term specifically refers to the capacity for rapid,

powerful muscle actions. Such strength is essential in many sports and physical activities that require quick and explosive movements, such as jumping, running, throwing, hitting, or quickly lifting heavy objects. Explosive strength not only involves raw muscle strength but also the neuromuscular coordination required to efficiently recruit and synchronize muscle groups for explosive actions (8).

The following outlines the procedures used to measure jumping ability through five tests, each assessing different movements and capacities in athletes:

- CounterMovement Jump (CMJ)
    - Double Leg (CMJ-DL)
    - Single Leg (CMJ-SL)
- Drop Jump (DJ)
- Single Hop for Distance Test (SHT) on one leg
- Triple Hop for Distance Test (THT) on one leg

Proper execution of these tests, by strictly following the standardized protocol, will yield accurate, valid, and reliable results, crucial for assessing athletes.

Knowing the validity and reliability of clinical tests is essential for correctly interpreting results, making informed decisions, and ensuring the quality of scientific research. Therefore, for the presented tests, scientifically-based information on reference values, validity, reliability, execution procedures, result analysis parameters, and recommendations for interpreting and visualizing the results will be provided.

Unit 1. Instrument

Unit 2. CounterMovement Jump (CMJ). Double Leg (DL) and Single Leg (SL)

- **Unit 3. Drop Jump (DJ)**
- **Unit 4. Single Hop for Distance Test (SHT) on one leg**
- **Unit 5. Triple Hop for Distance Test (THT) on one leg**

Unit 1. Instrument

Unit 1. Instrument

The CMJ-SL/DL and DJ jumps are measured using a Chronojump Boscosystem® contact platform (Barcelona, Spain), which is the size of a Din-A2 (420x590 mm). The system utilizes software that operates with open-source Chronopic hardware. It consists of a dual conductive contact bar connected to a skypic (Chronopic), which records time at a frequency of 1000 Hz. The skypic is connected to a PC running Chronojump software for data analysis. The system's validity and reliability have been studied to ensure accurate results (9).

These contact platforms are a cost-effective alternative to force platforms, estimating jump height based on flight time.

They are connected to an electronic compression-sensitive timing system that starts when the athlete's feet leave the ground and stops when they make contact again.

Contact platforms are tools used for measuring and analyzing jumps, allowing us to:

- Measure flight time and ground contact time accurately.
- Calculate jump height, force, and power.
- Facilitate the evaluation of different types of jumps, including vertical jumps, countermovement jumps, and drop jumps, using user-friendly software.

The THT and SHT jumps are measured using a tape measure that is fixed to the ground, which should be at least 6 meters long and 15 centimeters wide. This setup includes a clearly marked starting line and precise centimeter markings for accurately recording the jump distance.

References

(1) Markovic, G, Dizdar, D, Jukic, I, and Cardinale, M. Reliability and factorial validity of squat and countermovement jump tests. J Strength Cond Res 18: 551–555, 2004

(2) Stolen, T, Chamari, K, Castagna, C, and Wisloff, U. Physiology of soccer: An update. Sports Med 35: 501–536, 2005.

(3) Ziv, G and Lidor, R. Physical attributes, physiological characteristics, on-court performances and nutritional strategies of female and male basketball players. Sports Med 39: 547–568, 2009.

(4) Sheppard, JM, Cronin, JB, Gabbett, TJ, McGuigan, MR, Etxebarria, N, and Newton, RU. Relative importance of strength, power, and anthropometric measures to jump performance of elite volleyball players. J Strength Cond Res 22: 758–765, 2008

(5) Kruger, K, Pilat, C, Uckert, K, Frech, T, and Mooren, FC. Physical performance profile of handball players is related to playing position and playing class. J Strength Cond Res 28: 117–125, 2014x

(6)Alemdaroglu, U. The relationship between muscle strength, anaerobic performance, agility, sprint ability and vertical jump performance in professional basketball players. J Hum Kinet 31: 149–158, 2012.

(7) Cavagna GA. Storage and utilization of elastic energy in skeletal muscle. Exerc Sport Sci Rev 5: 89- 495 129, 1977

(8) Edman KA, Elzinga G, and Noble MI. Residual force enhancement after stretch of contracting frog 518 single muscle fibers. J Gen Physiol 80: 769-784, 1982.

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Unit 2. CounterMovement Jump (CMJ). Double Leg (DL) and Single Leg (SL)

Unit 2. CounterMovement Jump (CMJ). Double Leg (DL) and Single Leg (SL)

The CMJ is a widely used vertical jump test for evaluating lower body strength and power. It involves an initial countermovement before a toe-off phase. This countermovement includes a rapid knee and hip flexion followed by an explosive upward extension (1-3).

The CMJ test assesses the reactive strength of the lower limbs. It is a reliable and valid tool for use with both children and adults, including elite athletes. The jump height measured is directly related to muscle strength and other performance metrics such as speed, agility, and power (2,3).

The CMJ is not only effective for assessing lower body power in sports settings but also has significant applications in injury rehabilitation by focusing on strength training (2).

It is used to monitor neuromuscular status and functional recovery in patients during and after rehabilitation. This makes it highly useful for obtaining information on an athlete's acute or current status during rehabilitation, especially if performed under conditions of acute or chronic fatigue, and also provides objective data on the athlete's condition throughout the rehabilitation process (1,3).

By providing accurate information about the lower limbs' ability to generate force and power, the CMJ helps health professionals design and adjust rehabilitation programs effectively, which is crucial for preventing overtraining or under-recovery of strength, both of which are key elements in rehabilitation (1).

The Single Leg CMJ Jump (SLCMJ) is a variation of the traditional CMJ that evaluates unilateral lower limbs strength and power. This test is particularly valuable for identifying muscle imbalances between the legs, which is a major factor in injury prevention and rehabilitation. The SLCMJ demands greater stability and neuromuscular control, as the individual must balance and coordinate the movement on one leg during the jump. This test provides detailed information on each limb's stability and power, helping physiotherapists design more targeted and effective rehabilitation programs. Moreover, the SLCMJ is highly relevant in sports that require explosive unilateral movements, such as football, basketball, and athletics, helping improve performance and reduce injury risk in these disciplines (4).

Procedure (Double Leg)

This test utilizes a flight time measurement device (contact platform) and a computer equipped with Chronojump Boscosystem® software.

The subject stands on both feet on the contact platform with their hands placed on their hips. From the starting position, the subject performs a vertical jump as high as possible, allowing a countermovement of the lower limbs. The subject lands with knees extended. One trial jump is conducted, followed by three evaluation jumps, with rest periods allowed between repetitions if necessary (<30 seconds). The reference value is the highest jump, expressed in centimeters.

The test is performed wearing sports footwear.

Starting position

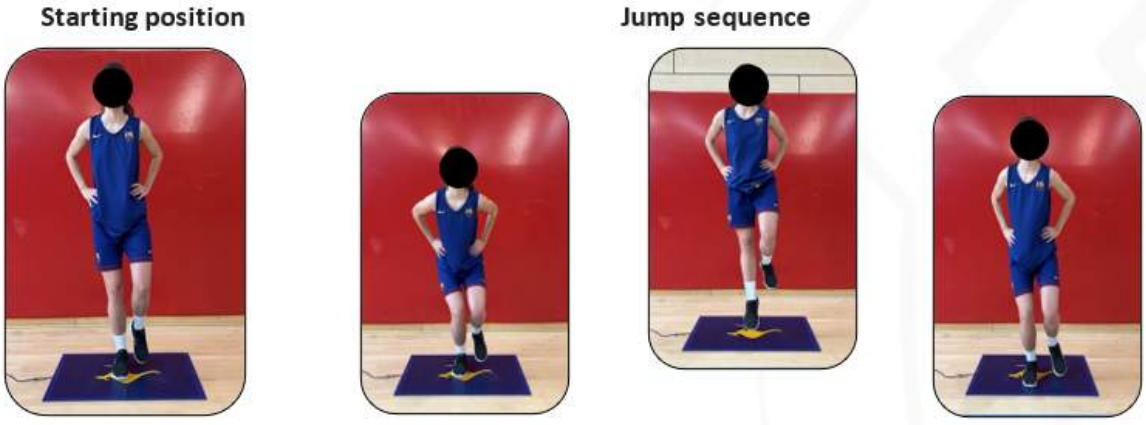
Jump sequence

Procedure (Single Leg)

This test utilizes a flight time measurement device (contact platform) and a computer equipped with Chronojump Boscosystem® software.

The subject stands on a single leg on the contact platform, with hands positioned on the hips. From the starting position, the subject performs a vertical jump as high as possible, allowing a countermovement of the lower limbs. The subject lands with knees extended, avoiding stabilization hops. One trial jump is conducted, followed by three evaluation jumps, with rest periods allowed between repetitions if necessary (<30 seconds). The reference value is the highest jump, expressed in centimeters.

The test is performed wearing sports footwear.



Analysis, interpretation, and visualization of results

A countermovement jump (CMJ) is a simple, practical, valid, and reliable measure primarily used to assess lower-body power in athletes (5, 7). It helps identify strengths and weaknesses and can track both training progress (1) and recovery following injury, up to their Return to Play.

This test can be performed with two legs (CMJ Double Leg) or one leg (CMJ Single Leg) and is used to assess:

- Explosive strength – CMJ Double Leg is the gold standard for lower body performance (5).
- Lower-body power.
- Fatigue levels and supercompensation based on individual data. (5)
- Maximum strength, sprinting ability, and direction-changing capacity. (6)
- Lower-body stability and proprioception.
- The CMJ Single Leg Test is reliable for evaluating knee function after ACL reconstruction. (5)

To analyze CMJ performance, the height reached (in cm) from each of the three jumps during the monitoring session is used to calculate the average for correlation analysis (9). In terms of vertical jump performance, flight time—the total time the athlete remains airborne without ground contact—is considered the most valid and reliable method for calculating jump height (8, 9).

Once the results are obtained, we will perform a quantitative comparison between:

- The same player at different times (preseason and during the current season, pre/post-injury, and different recovery phases).
- The right and left leg in the case of a Single Leg CMJ.
- Athletes in the same sport modality.
- Athletes playing in the same position or with similar characteristics from the same team.

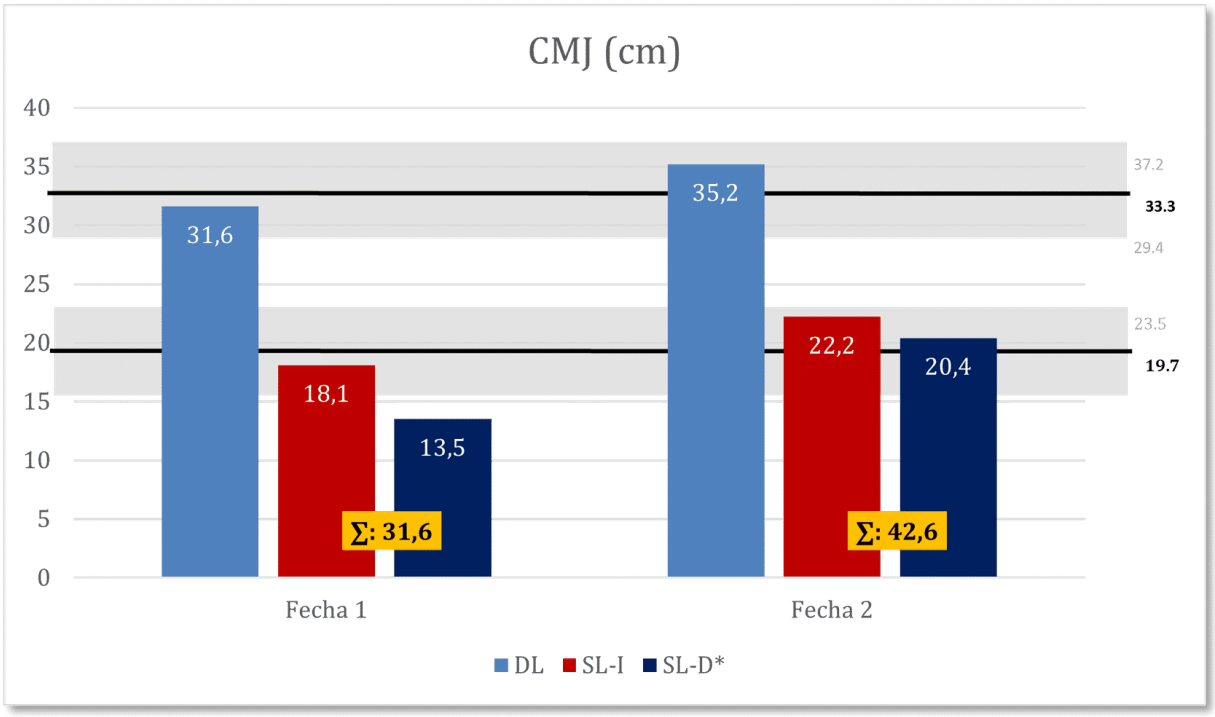
At a qualitative level, it is important to perform the analysis alongside a 2D video, primarily assessing the presence of knee valgus, taking into account any potential inward oscillation or movement of the knees, and/or contact between them.

Given that the subjects are athletes, the reference values obtained from FC Barcelona in the 2022-23 season for this test are as follows (expressed in cm):

Double Leg (DL):	**Single Leg (SL):**
Futsal: 33.3 ± 3.9	*Futsal:* 19.7 ± 3.8
Women's football: 28.1 ± 5.3	*Women's football:* 15.2 ± 2.6
Rink hockey: 32.4 ± 4.9	*Basketball:* 18.4 ± 2.9

This indicates variability in the results depending on the type of sport practiced.

Below is a potential graphical interpretation (Graph 1) of the results from a CMJ jump, both double-leg (DL) and single-leg (SL), performed by an athlete from FC Barcelona during lower limb injury rehabilitation.



Graph 1. Visual representation of CMJ DL and SL results, including the sum of both one-leg jumps, for an FCB athlete undergoing rehabilitation, taken on two different dates (Fecha 1 and Fecha 2).

Fecha = Date

The graph shows the results of both tests on two separate dates, with the injured leg marked by an asterisk (*).

It is advisable to visualize both CMJs (DL and SL) on the same graph to reference jump distance (in cm) for both two-leg and single-leg jumps. This allows for attention to be given to the difference between legs and the total result from each leg separately.

Similarly, it is useful to compare these jumps with the group average, highlighting the individual's position relative to the group mean (black line) and within one standard deviation (gray box).

CMJ (DL)

Instrument: Chronojump Boscosystem® contact platform and a PC with the specific software.

Subject's position: double-leg stance on the contact platform, with hands on hips.

Execution: the subject performs a vertical jump as high as possible, allowing countermovement of the lower limbs.

Measurements: one trial jump and three evaluation jumps are performed, with rest between repetitions if needed (<30 seconds). The highest jump (in cm) is selected as the reference value.

CMJ (SL)

Instrument: Chronojump Boscosystem® contact platform and a PC with the specific software.

Subject's position: single-leg stance on the contact platform, with hands on the hips.

Execution: the subject performs a vertical jump as high as possible, allowing countermovement of the lower limbs.

Measurements: one trial jump and three evaluation jumps are performed, with rest between repetitions if needed (<30 seconds). The highest jump (in cm) is selected as the reference value.

References

(1) Claudino JG, Cronin J, Mezêncio B, et al. The countermovement jump to monitor neuromuscular status: a meta-analysis. J Sci Med Sport. 2016;19(3):396-402. doi:10.1016/j.jsams.2016.08.011.

(2) Berton R, Lixandrão ME, Pinto e Silva CM, Tricoli V. Effects of weightlifting exercise, traditional resistance and plyometric training on countermovement jump performance: a meta-analysis. J Sports Sci. 2018;36(18):2038-2044. doi:10.1080/02640414.2018.1434746.

(3) Petrigna L, Karsten B, Marcolin G, et al. A review of countermovement and squat jump testing methods in the context of public health examination in adolescence: reliability and feasibility of current testing procedures. Front Physiol. 2019;10:1384. doi:10.3389/fphys.2019.01384.

(4) Gonzalo-Skok O, Moreno-Azze A, Arjol-Serrano JL, Tous-Fajardo J, Bishop C. A Comparison of 3 Different Unilateral Strength Training Strategies to Enhance Jumping Performance and Decrease Interlimb Asymmetries in Soccer Players. Int J Sports Physiol Perform. 2019;14(9):1256-1264. doi:10.1123/ijspp.2018-0920

(5) Markovic G, Dizdar D, Jukic I, Cardinale M. Reliability and factorial validity of squat and countermovement jump tests. J Strength Cond Res. 2004;18(3):551-555. doi:10.1519/1533-4287(2004)18<551:RAFVOS>2.0.CO ;2

(6) Rodríguez-Rosell D, Mora-Custodio R, Franco-Márquez F, Yáñez-García JM, González-Badillo JJ. Traditional vs. Sport-Specific Vertical Jump Tests: Reliability, Validity, and Relationship With the Legs Strength and Sprint Performance in Adult and Teen Soccer and Basketball Players. J Strength Cond Res. 2017;31(1):196-206. doi:10.1519/JSC.0000000000001476

(7) Rago V, Brito J, Figueiredo P, et al. Countermovement Jump Analysis Using Different Portable Devices: Implications for Field Testing. Sports (Basel). 2018;6(3):91. Published 2018 Aug 31. doi:10.3390/sports6030091

(8) Dias JA, Dal Pupo J, Reis DC, et al. Validity of two methods for estimation of vertical jump height. J Strength Cond Res. 2011;25(7):2034-2039. doi:10.1519/JSC.0b013e3181e73f6e

(9) Balsalobre-Fernández C, Tejero-González CM, del Campo-Vecino J, Bavaresco N. The concurrent validity and reliability of a low-cost, high-speed camera-based method for measuring the flight time of vertical jumps. J Strength Cond Res. 2014;28(2):528-533. doi:10.1519/JSC.0b013e318299a52e

Unit 3. Drop Jump (DJ)

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The Drop Jump (DJ) is a test widely used to assess reactive power and the stretch-shortening cycle ability of lower limb muscles. The test involves dropping from a platform and, upon ground contact, performing an explosive jump aiming at minimizing ground contact time and maximizing jump height. This test is essential for evaluating reactive power and explosive strength in leg muscles, both of which are fundamental in sports requiring rapid changes in direction and repeated jumping (1,2).

The DJ can be performed bilaterally or unilaterally to identify asymmetries between limbs. Asymmetries detected through DJ can highlight muscular imbalances that may predispose athletes to injury. For example, DJ evaluations have been shown to effectively identify significant strength and stability differences between limbs, which is crucial for designing personalized training programs that address these imbalances and reduce injury risk (2).

The DJ and Single-Leg Drop Jump (SLDJ) are particularly useful in rehabilitation, as they help assess the muscles' ability to produce quick, powerful contractions after stretching, known as reactive capacity. This is particularly important for athletes recovering from injuries, as strong reactive ability helps prevent re-injury and enhances overall sports performance (2).

Regular assessment using DJ allows physiotherapists to monitor improvements in reactive ability and adjust training programs accordingly. This test is used to measure changes in neuromuscular function during post-ACLR (anterior cruciate ligament reconstruction) rehabilitation, helping make better decisions about returning to sports activity (2).

The DJ test is an effective tool for identifying weaknesses that may make athletes more prone to injury. Regular assessment with DJ helps spot these weaknesses and allows physiotherapists to develop targeted training programs to correct imbalances. This is especially relevant in injury rehabilitation and re-injury prevention, ensuring a complete and safe recovery before returning to sports (3).

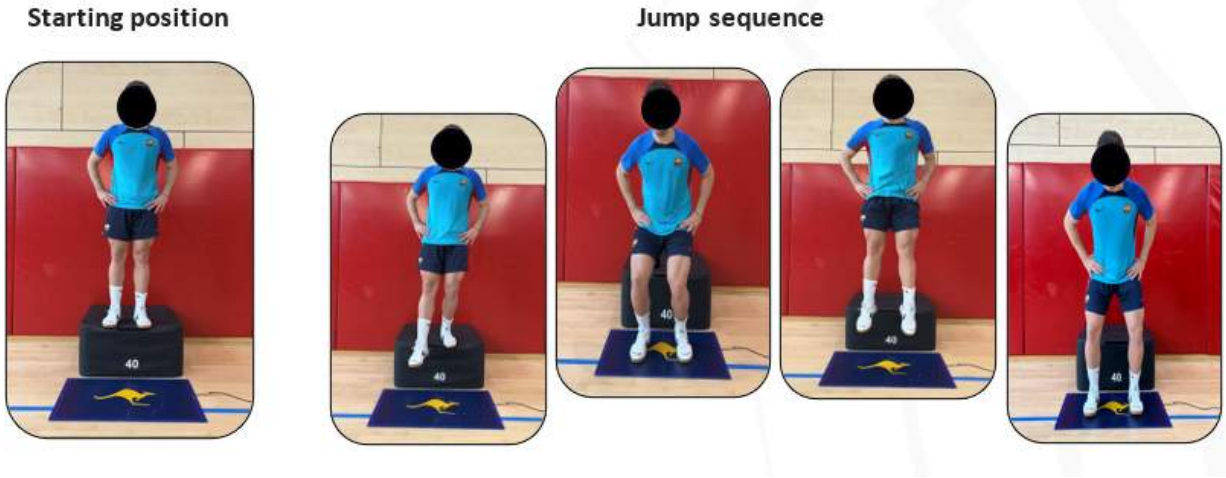
Procedure (Double Leg)

The test uses flight time measurement equipment (contact platform), a computer with Chronojump Boscosystem® software, and a 40 cm-high box.

From the initial position, standing on top of the box, the athlete steps forward off the box with one foot. Upon landing, they must quickly decelerate and immediately perform a maximal vertical jump with both legs.

One trial jump and two test jumps are performed, with rest periods between jumps if needed (<30 seconds). The maximum jump height serves as the reference point.

The test is performed wearing sports footwear.



Analysis, interpretation, and visualization of results

The Drop Jump (DJ), also known as a reactive jump test (4, 5), is commonly used to measure reactive jump ability (6), or the effectiveness of the stretch-shortening cycle. Assessing how athletes can quickly and effectively transition from eccentric to contraction—

an expression of their dynamic explosive capacity in vertical jump (reactive strength index or RSI)—helps us understand how their bodies adapt to the stress induced by plyometric actions. Like other jump tests, this one helps monitor training, player fatigue, and the recovery process following injury until the athlete's Return to Play.

The Drop Jump can be performed with both legs (DJ Double Leg) or one leg (DJ Single Leg). This module focuses on the double leg version, which relates to:

- Sprinting, speed, and neuromuscular fatigue (7).
- ACL injury (8, 9)

For the quantitative analysis of DJ, factors such as jump height (HJ), flight time (FT), contact time (CT), reactive strength index (RSI), and average power are considered. Once results are gathered, we compare:

- The same player at different times (preseason and during the current season, pre/post-injury, and different recovery phases).
- The right and left legs, in case of performing DJ Single Leg.

- Athletes in the same sport modality.
- Athletes playing in the same position or with similar characteristics from the same team.

For qualitative analysis, a 2D video is used to evaluate the injury risk index (9), focusing on the valgus angle as a risk factor (8, 9), with a 3-level scoring system at four key moments during the jump:

- 1st moment: Initial contact.
- 2nd moment: First landing at maximum valgus.
- 3rd moment: Second landing at maximum valgus.
- 4th moment: Maximum valgus point in both jumps.

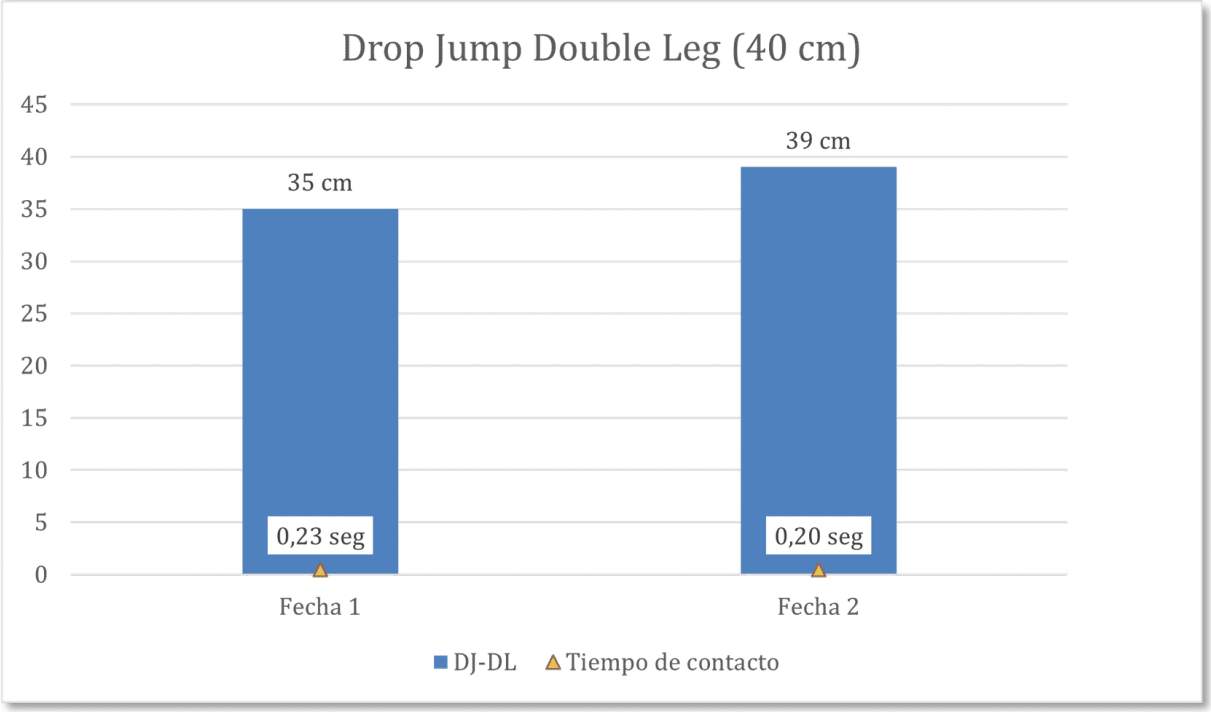
Scoring:

- 1 point: No knee valgus – angle less than 10.83º (8).
- 2 points: Slight knee inward movement and/or oscillation.
- 3 points: Knee collision and/or significant forward movement.

Unlike other tests in the module, we do not have reference values (averages) documented in any of the professional sections of FC Barcelona. However, a sample graph (Graph 2) is provided here, illustrating the results of a specific test conducted with an athlete from FC Barcelona.

This graph shows the time evolution of two DJ-type jumps with both legs (DL), illustrating the distances covered and contact times for each jump.

As shown, it's important to note the increase in jump distance and decrease in contact time, indicating good progress in the athlete's training.



Graph 2. Visual representation of the progression of two DJ-DL jumps from a 40-cm box, showing the contact time for each jump (yellow triangle) and the distances reached in each measurement.

En el gráfico: Fecha = Date | Tiempo de contacto = Contact Time

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DJ - Double Leg

Instrument: Chronojump Boscosystem® contact platform, PC with the specific software, and a 40-cm box.

Subject's position: standing on the 40-cm box.

Execution: the subject steps off the box by moving one foot forward. Upon landing, they should decelerate quickly and immediately perform a maximal vertical jump with both legs.

Measurements: one trial jump and two test jumps are performed, with rest periods between jumps if needed (<30 seconds). The maximum jump height serves as the reference point.

References

(1) Gashi F, Kovacic T, Gashi AI, Boshnjaku A, Shalaj I. Predicting Risk Factors of Lower Extremity Injuries in Elite Women's Football: Systematic Review and Meta-Analysis. Sports (Basel). 2023;11(9):187. doi:10.3390/sports11090187.

(2) Labban W, Manaseer T, Golberg E, et al. Jumping into recovery: A systematic review and meta-analysis of discriminatory and responsive force plate parameters in individuals following anterior cruciate ligament reconstruction during countermovement and drop jumps. J Exp Orthop. 2024;11:e12018. doi:10.1002/jeo2.12018.

(3) Tong Z, Chen W, Xu H, Zhai F. Optimal Loading Height: A Practical Research of Drop Jump from Biomechanics. J Healthc Eng. 2022;2022:4173639. doi:10.1155/2022/4173639.

(4) Walsh M, Arampatzis A, Schade F, Brüggemann GP. The effect of drop jump starting height and contact time on power, work performed, and moment of force. J Strength Cond Res. 2004;18(3):561-566. doi:10.1519/1533-4287(2004)18<561:TEODJS>2.0.CO;2

(5) Ball NB, Stock CG, Scurr JC. Bilateral contact ground reaction forces and contact times during plyometric drop jumping. J Strength Cond Res. 2010;24(10):2762-2769. doi:10.1519/JSC.0b013e3181cc2408

(6) Flanagan EP, Ebben WP, Jensen RL. Reliability of the reactive strength index and time to stabilization during depth jumps. J Strength Cond Res. 2008;22(5):1677-1682. doi:10.1519/JSC.0b013e318182034b

(7) Bosco C. (1994). La valoración de la fuerza con el test de Bosco. Paidotribo.

(8) Ekegren CL, Miller WC, Celebrini RG, Eng JJ, Macintyre DL. Reliability and validity of observational risk screening in evaluating dynamic knee valgus. J Orthop Sports Phys Ther. 2009;39(9):665-674. doi:10.2519/jospt.2009.3004

(9) Beyer EB, Hale RF, Hellem AR, Mumbleau AM, Schilaty ND, Hewett TE. INTER AND INTRA-RATER RELIABILITY OF THE DROP VERTICAL JUMP (DVJ) ASSESSMENT. Int J Sports Phys Ther. 2020;15(5):770-775. doi:10.26603/ijspt20200770

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Unit 4. Single Hop for Distance Test (SHT) on one leg

Unit 4. Single Hop for Distance Test (SHT) on one leg

The Single Hop Test (SHT) is a widely utilized jump assessment for evaluating recovery following medium- to long-term injury rehabilitation. Its main purpose is to measure the functional capacity of the injured limb in comparison to the healthy limb, employing the Limb Symmetry Index (LSI) as a quantitative measure. This test helps assess the strength, power, and neuromuscular control of the lower limb—key factors in making RTS decisions (1,2).

The SHT is typically performed multiple times throughout the rehabilitation phase to track the patient's functional progress. This includes both early and advanced, depending on the type of injury. For instance, in the case of anterior cruciate ligament rehabilitation, it can be performed from approximately 12 weeks post-surgery to 52 weeks post-surgery (2).

This test is especially relevant because it provides objective data on the functional recovery of the lower limb. The test is safe and suitable for assessing strength and functional ability throughout the

rehabilitation process. Its simplicity and minimal equipment requirements make it an accessible and effective tool for physical therapists in the ongoing evaluation of patient progress (1).

It is an essential tool in the rehabilitation of elite athletes following various lower limb injuries. It allows physical therapists to objectively monitor functional recovery, tailor rehabilitation programs to the specific needs of each patient, and make informed decisions about their return to sport, thereby minimizing the risk of re-injury and ensuring complete and safe recovery (2).

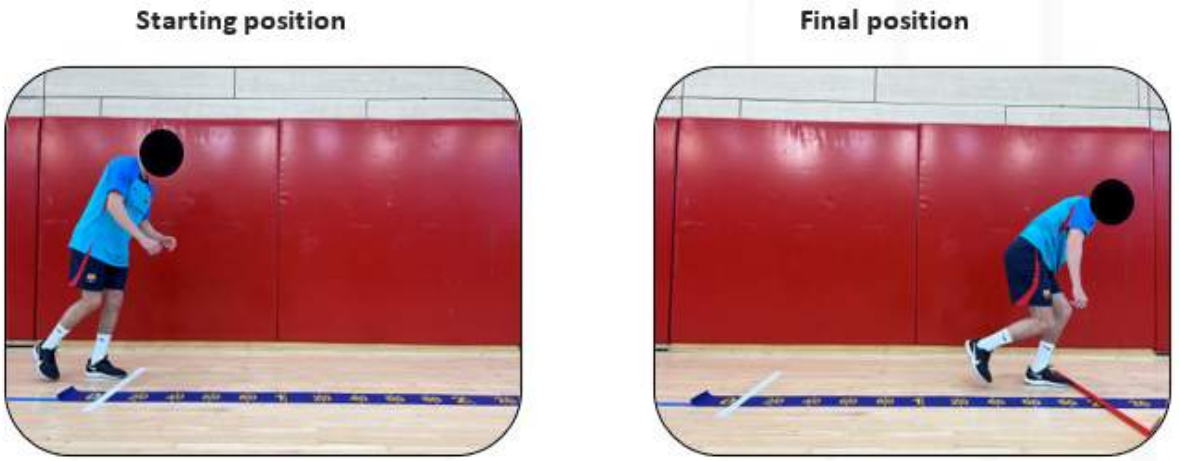
Procedure

To conduct the test, a starting line should be marked on a tape measure. The subject's initial position is in a single-leg stance behind the starting line. From this position, the subject performs a maximum horizontal jump, landing on the evaluated limb. Arm swinging is permitted during the jump. A jump is deemed invalid if the opposite limb or either upper limb touches the ground, or if stabilization hops and/or a loss of stability occur within two seconds of landing.

The distance is measured from the initial position to the front of the shoe, rounding to the nearest centimeter. One trial jump and two test jumps are performed for each limb, with rest periods between jumps if needed (<30 seconds). The reference is the maximum distance achieved.

The test is performed wearing sports footwear.

A two-minute rest period must be allowed between different types of horizontal jump tests.



Analysis, interpretation, and visualization of results

One commonly used functional test following ACL reconstruction is the Single Hop for Distance Test (SHT). Conducting this test requires a minimum level of strength, power, and neuromuscular control, making it a valuable tool for detecting asymmetries between the lower limbs. A successful performance also provides psychological reassurance to the athlete, serving as an objective measure for assessing recovery progress and aiding in decision-making for the next phase of rehabilitation. (4)

The Single Hop for Distance Test (SHT) is related to:

- Lower limbs functionality during ACL recovery. (1)
- Decision-making criteria for Return to Sport and Return to Play following a lower limb injury, primarily involving the knee joint. (2, 3)
- Anterior cruciate ligament injury. (3)

This test is generally reported using the Limb Symmetry Index (LSI), which is the ratio of the distance jumped by the injured limb divided by the distance jumped by the healthy limb, multiplied by 100. (2, 4). For the test to be considered normal, the LSI must be greater than 85%, meaning there is less than a 15% asymmetry between the limbs (3). To make informed decisions during ACL recovery, it is essential for patients to reach specific benchmarks in their limb symmetry index (LSI). An LSI of at least 85% is required to move to Return to Sport-1. To progress to the next phase, Return to Sport-2, an LSI greater than 90% is necessary. For athletes' Return to Competition in pivot or contact sports, an LSI above 100% is required. (4)

However, the literature indicates that the sensitivity of the limb symmetry index in detecting functional abnormalities is questionable, primarily due to methodological inconsistencies. Notably, common

assessment methods often rely on a limited number of jump repetitions without accounting for repeated maximum performance or the effects of fatigue (including failed attempts) on peak performance—factors that play a crucial role in high-level sports (4).

Once the results are obtained, quantitative comparisons are made between:

- The same player at different times (preseason and during the current season, pre/post-injury, and different recovery phases).
- Athletes in the same sport modality.
- Athletes playing in the same position or with similar characteristics from the same team.

At a qualitative level, it is important to perform the analysis alongside a 2D video. The SHT can identify kinematic and kinetic deficits between limbs following ACL reconstruction, even when performance appears adequate. Solely measuring jump distance, regardless of using the healthy leg as a reference, falls short of providing a comprehensive evaluation of knee function. (3)

Given that the subjects are athletes, the reference values obtained from FC Barcelona in the 2022-23 season for this test are as follows (expressed in cm):

Basketball: 192.8 ± 22.5

Futsal: 212.4 ± 19.1

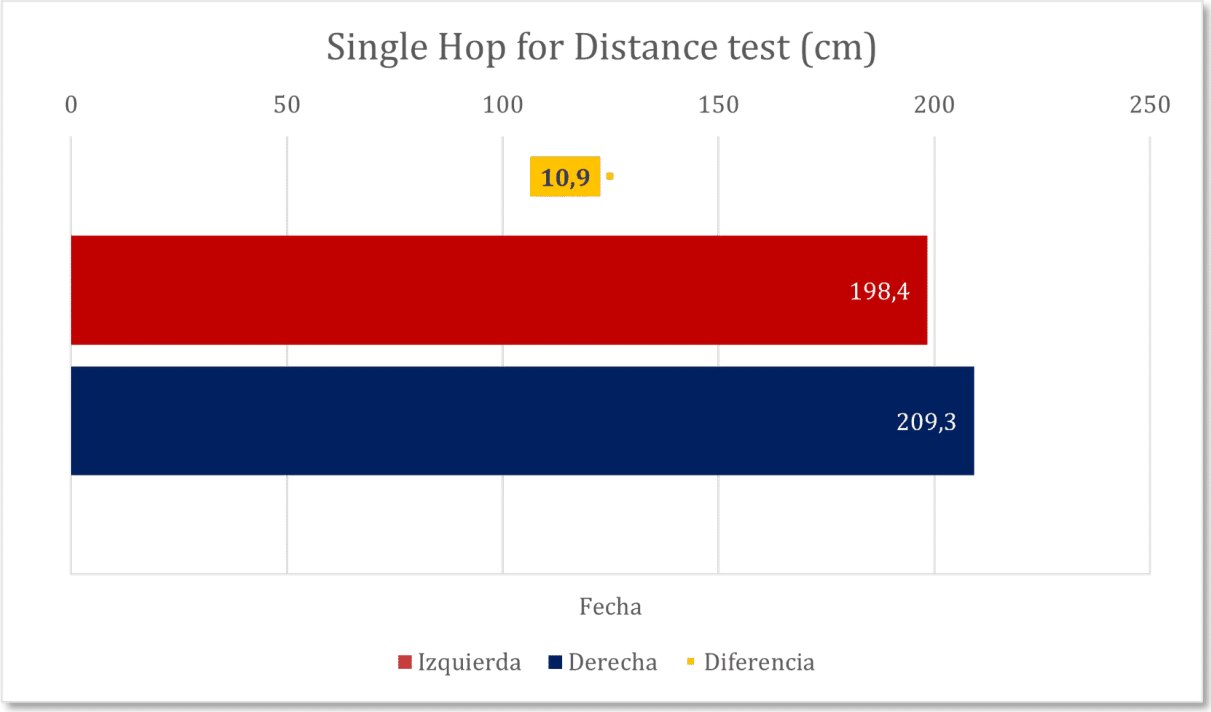
Women's football: 157.1 ± 18.3

Rink hockey: 156.8 ± 17.1

This indicates variability in the results depending on the type of sport practiced.

Below is a graphical representation (Graph 3) of the results obtained from a SHT conducted on an athlete from FC Barcelona. It illustrates the distance achieved by each limb, highlighting the differences between them, and positioning these results in relation to the group. The black line indicates the average, while the gray box represents one standard deviation.

Having all this data in a single graph provides a quick overview of the athlete's situation, which is crucial for informing decision-making in injury rehabilitation processes or detecting potential deficits to address in healthy athletes.



Fecha = Date | Izquierda = Left | Derecha = Right | Diferencia = Difference
Graph 3. Visual representation of the jump distance (in cm) for each leg in the SHT, indicating the difference between the two legs and showing the athlete's position relative to the group average and one standard deviation for this test. (Red, Left leg; blue, Right leg; yellow, Difference)

Single Hop for Distance Test

Instrument: tape measure with a marked starting line.

Subject's position: single-leg stance behind the starting line.

Execution: the subject performs a maximum horizontal jump, landing on the assessed limb.

Measurements: one trial jump and two test jumps are performed, with rest periods between jumps if needed (<30 seconds). The reference is the maximum distance achieved.

References

(1) Measson MV, Ithurburn MP, Rambaud AJM. Intra-rater reliability of a qualitative landing scale for the single-hop test: A pilot study. Int J Sports Phys Ther. 2022;17(3):493-500. doi:10.26603/001c.33066.

(2) Rambaud AJM, Rossi J, Neri T, Samozino P, Edouard P. Evolution of functional recovery using hop test assessment after ACL reconstruction. Int J Sports Med. 2020;41(10):696-704. doi:10.1055/a-1122-8995.

(3) Kotsifaki A, Korakakis V, Whiteley R, Van Rossom S, Jonkers I. Measuring only hop distance during single leg hop testing is insufficient to detect deficits in knee function after ACL reconstruction: a systematic review and meta-analysis. Br J Sports Med. 2020;54(3):139-153. doi:10.1136/bjsports-2018-0999

(4) Judd A, Sharp T. The Single Hop for Distance Test: Reviewing the Methodology to Measure Maximum and Repeated Performance [published correction appears in J Sport Rehabil. 2022 Aug

04;31(8):1075]. J Sport Rehabil. 2022;31(5):657-663. Published 2022 Mar 12. doi:10.1123/jsr.2021-0242

Unit 5. Triple Hop for Distance Test (THT) on one leg

Unit 5. Triple Hop for Distance Test (THT) on one leg

The THT is a widely used functional test to assess lower limb strength, power, and stability, particularly in the context of rehabilitation and sports reconditioning. This test requires athletes to perform three consecutive jumps on one leg, measuring the total distance covered. The THT has proven to be a reliable and valid tool for assessing athletes' functional capacity (1,2).

The THT is used to measure lower limb strength and power, providing a quantitative assessment of athletic performance. This is crucial for determining an athlete's recovery status after an injury, especially to the knee and ankle.

The THT can also identify potential asymmetries in knee function, even when jump distances appear symmetrical. This information is valuable for physiotherapists, as these asymmetries may indicate muscular imbalances or residual weaknesses that could increase the risk of re-injury (2).

The results of the THT can help physiotherapists create personalized rehabilitation programs. By pinpointing areas of weakness or functional deficits, specific exercises can be developed to improve stability, strength, and coordination in the affected limb (1).

Therefore, the THT is often used in return-to-sport evaluations to assess whether an athlete is ready to resume competition. A satisfactory performance on this test, along with other clinical criteria, can help healthcare professionals make positive decisions regarding the athlete's safe return to their sport (1,2).

Procedure

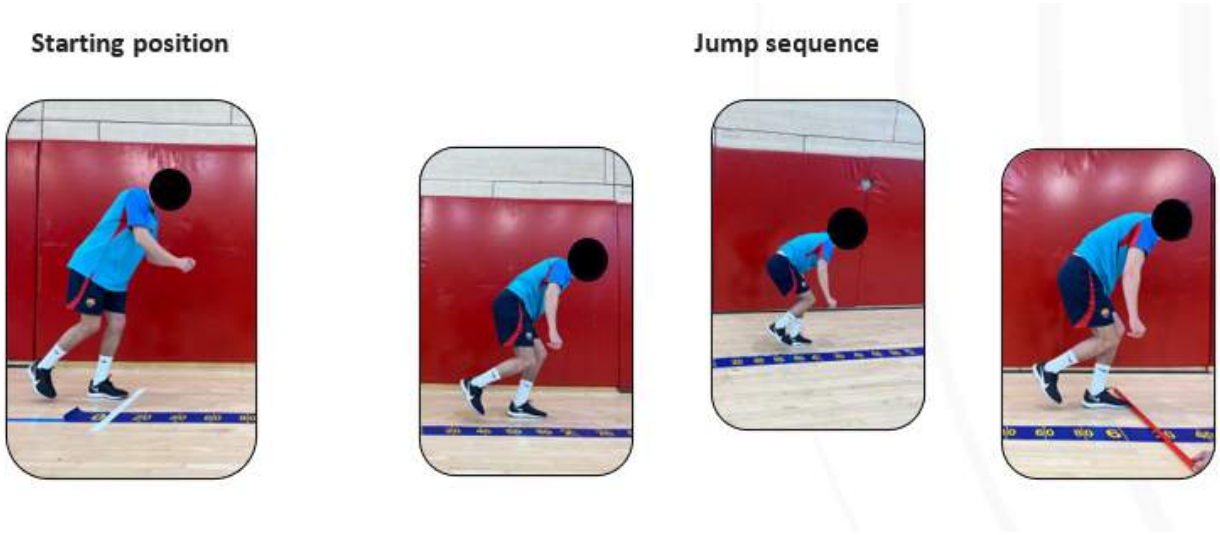
To conduct the test, a starting line should be marked on a tape measure. The subject's initial position is in a single-leg stance behind the starting line. From this position, three maximum horizontal jumps are performed consecutively, always landing on the assessed limb. Arm swinging is permitted during the jumps. A jump is deemed invalid if the opposite limb or either upper limb touches the ground, or if stabilization hops and/or a loss of stability occur within two seconds of landing.

The distance is measured from the initial position to the front of the shoe, rounding to the nearest centimeter. One trial jump and two test jumps are performed for each limb, with rest periods between jumps if

needed (<30 seconds). The reference is the maximum distance achieved.

The test is performed wearing sports footwear.

A two-minute rest period must be allowed between different types of horizontal jump tests.



Analysis, interpretation, and visualization of results

Similar to the Single Hop for Distance Test (SHT), the Triple Hop for Distance Test (THT) is one of the most commonly used functional tests following ACL reconstruction. Like the SHT, the execution of the THT requires a minimum of strength, power, and neuromuscular control, making it an objective measure to consider during the recovery process, which is crucial for decision-making required for progressing to the next phase. (5)

The Triple Hop for Distance Test (THT) relates to:

- Lower limbs functionality during ACL recovery (3).
- Decision-making criteria for Return to Sport and Return to Play following a lower limb injury, primarily involving the knee joint (3, 4).
- Anterior cruciate ligament (3).

This test, similar to the SHT, is reported using the limb symmetry index (LSI), which is the ratio of the distance of the injured limb to the distance of the healthy limb, multiplied by 100. (4,5) An LSI greater than 85% is considered normal, indicating an asymmetry of 15% or more between limbs. To make informed decisions during ACL recovery, an LSI of at least 85% is required to move to Return to Sport-1. To progress to the next phase, Return to Sport-2, an LSI greater than 90% is necessary. For athletes' Return to Competition in pivot or contact sports, an LSI above 100% is required. (5)

Once the results are obtained, we will perform a quantitative comparison between:

- The same player at different times (preseason and during the current season, pre/post-injury, and different recovery phases).
- Athletes in the same sport modality.
- Athletes playing in the same position or with similar characteristics from the same team.

At a qualitative level, it is important to perform the analysis alongside a 2D video. The THT, like the SHT, can identify kinematic and kinetic deficits between limbs following ACL reconstruction, even when performance in SLHD appears adequate. Solely measuring jump distance, regardless of using the healthy leg as a reference, falls short of providing a comprehensive evaluation of knee function (3)

Given that the subjects are athletes, the reference values obtained from FC Barcelona in the 2022-23 season for this test are as follows (expressed in cm):

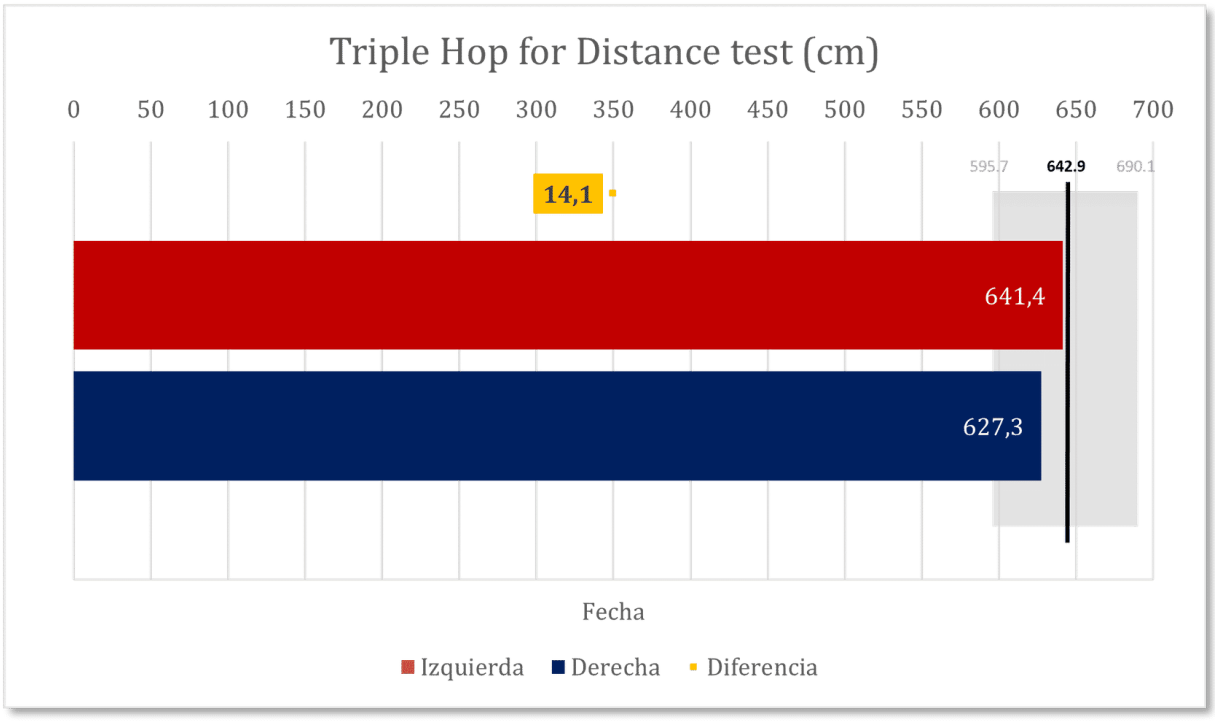
Women's football: 490.8 ± 47.1

Futsal: 642.9 ± 47.2

This indicates variability in the results depending on the type of sport practiced.

Below is a graphical representation (Graph 4) of the results obtained from a THT conducted on an athlete from FC Barcelona. It illustrates the distance achieved by each limb, highlighting the differences between them, and positioning these results in relation to the group. The black line indicates the average, while the gray box represents one standard deviation.

Combining the results of this test with those of the previously described SHT can improve the ability to detect asymmetry between the lower limbs, allowing professionals to make more precise decisions during rehabilitation processes, such as for the anterior cruciate ligament.



Fecha = Date | Izquierda = Left | Derecha = Right | Diferencia = Difference

Graph 4. Visual representation of the jump distance (in cm) for each leg in the THT, indicating the difference between the two legs and showing the athlete's position relative to the group average and one standard deviation for this test. (Red, Left leg; blue, Right leg; yellow, Difference)

Triple Hop for Distance Test

Instrument: tape measure with a marked starting line.

Subject's position: single-leg stance behind the starting line.

Execution: the subject performs three consecutive maximum horizontal jumps, always landing on the evaluated limb.

Measurements: one trial jump and two test jumps are performed, with rest periods between jumps if needed (<30 seconds). The reference is the maximum distance achieved.

References

(1) Alvim FC, Lucareli PRG, Menegaldo LL. Predicting muscle forces during the propulsion phase of single leg triple hop test. Gait Posture. 2017;57:182-188. doi:10.1016/j.gaitpost.2017.07.038.

(2) Farraye BT, Simon JE, Chaput M, Kim HW, Monfort SM, Grooms DR. Development and reliability of a visual-cognitive reactive triple hop test. J Sport Rehabil. doi:10.1123/jsr.2022-0398.

(3) Kotsifaki A, Korakakis V, Whiteley R, Van Rossom S, Jonkers I. Measuring only hop distance during single leg hop testing is insufficient to detect deficits in knee function after ACL reconstruction: a systematic review and meta-analysis. Br J Sports Med. 2020;54(3):139-153. doi:10.1136/bjsports-2018-099918

(4) Rambaud AJM, Rossi J, Neri T, Samozino P, Edouard P. Evolution of Functional Recovery using Hop Test Assessment after ACL Reconstruction. Int J Sports Med. 2020;41(10):696-704. doi:10.1055/a-1122-8995

(5) Judd A, Sharp T. The Single Hop for Distance Test: Reviewing the Methodology to Measure Maximum and Repeated Performance [published correction appears in J Sport Rehabil. 2022 Aug 04;31(8):1075]. J Sport Rehabil. 2022;31(5):657-663. Published 2022 Mar 12. doi:10.1123/jsr.2021-0242

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